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FIELD MEASUREMENTS PLAN FOR THE SPR GEOTECHNICAL PROGRAM

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CONTENTS

I. INTRODUCTION

A. Objective

As a task assigned to the Sandia National Laboratories (SNL) Geotechnical Program by the Strategic Petroleum Reserve Project Management Office (SPRPMO) in New Orleans, the field measurements capabilities will be implemented to support the other Sandia tasks. These measurements will provide a sufficiently comprehensive data base to support the DOE SPR program in the preparation and operation of the SPR crude oil storage sites. The geotechnical program tasks to which the field measurements task is directly related are: (1) long-term monitoring, (2) engineering evaluation, and (3) site characterization. This plan will be periodically updated to reflect additional measurements to be utilized in the various Sandia tasks.

B. Implementation

The evaluation of measurement techniques and instrumentation systems will be performed primarily at the Bayou Choctaw SPR site beginning during the first quarter of FY81. The Bayou Choctaw site was chosen as a field evaluation site because:

(1) It includes caverns with possible geotechnical problem areas such as the caverns 15-17 separation and the cavern 4 subsidence.

(2) Only one new cavern is planned. This will allow evaluation of instrumentation for the Phase II caverns while the sub-surface activity is limited compared to West Hackberry and Bryan Mound.

(3) Two coreholes have already been drilled into the top of the dome.

(4) Oil storage caverns exist on the site.

(5) At least one cavern (#2) is predicted to be pressure tight, but is not planned for oil storage.

The instrumentation evaluated at Bayou Choctaw will be either procured from commercial sources and tested as received, procured and modified prior to test, or developed for a specific application.

II. MEASUREMENT REQUIREMENTS

The instrumentation systems and measurement techniques which will be evaluated in this program are necessary for acquisition of site characterization and engineering evaluation data and for developing long-term monitoring procedures.

The initial planning for the field tests includes the following types of measurements to be made. Additional measurements may prove necessary in achieving the final goals.

A. Site Characterization

It is necessary to define the separation between some caverns and the edge of their respective domes more accurately.
Cavern-dome edge separation data will be developed by methods using instrumentation techniques evaluated for that purpose. Radar systems and seismic transducers (cross hole and surface-to-hole) are presently considered prime candidates for these measurements.

B. Engineering Evaluation

Measurements used for validation of some mathematical modeling and material properties investigations for certification and recertification of new or existing caverns, for fluid flow dynamics, for intercavern web thickness verificaiton, for cavern size and shape, and for deformation will be evaluated.

Instrumentation which will measure wellhead pressure, fluid temperature, borehole deformation, surface deformation and acoustic emissions will be evaluated for use in cavern (re)certification. Commercially available wellhead pressure instrumentation (including that employed by commercial testing companies) and temperature logging tools will be evaluated for use in cavern (re)certification. It is expected that the pressure instrumentation with slight modifications will be adequate, but development of a more accurate temperature logging tool with higher resolution (0.01°C) will be necessary. The highest resolution advertised by logging companies is 0.1°C.

In order to measure the movement of the cavern roof during a pressure test, cavern instrumentation which will be installed in the borehole between the casing seat and the top of the cavern will be developed and evaluated.

It may be possible to relate surface deformation. to cavern roof movement. Therefore, instrumentation such as tiltmeters will be evaluated because it is expected that surface deformation measurements will be less expensive than the borehole deformation measurements.

Acoustic emission monitoring instrumentation will be evaluated in an attempt to develop measurement techniques which can detect the magnitude and location of salt cracks, roof slip and roof fall which may occur during cavern pressurization or depressurization.

Cavern fluids dynamics instrumentation planned to be evaluated are anemometers designed to detect very low flow. It may be necessary to develop fluid flow direction instrumentation.

Web thickness between caverns measurement techniques using sonar, radar and hole-to-hole seismic systems will be evaluated.

In addition to the present sonar survey methods, sonar calipers in oil will be evaluated for making cavern size and shape measurements.

C. Long-Term Monitoring (Ref 1)

Some long-term monitoring techniques will result from developments and evaluation performed because of site characterization and engineering evaluation requirements. Additional development and field evaluaton will be implemented for specific long-term monitoring instrumentation. All of the instrumentation developed or evaluated for long-term monitoring will acquire data of anticipated phenomena related to either cavern integrity, site stability or stored oil quality or quantity.

(1) Cavern Integrity

(a) Subsidence - Tiltmeters will be evaluated for monitoring subsidence of the surface above caverns.

(b) Web thickness - Borehole-to-borehole and borehole-to-surface seismic techniques will be evaluated as techniques to determine the thickness of salt between caverns.

(c) Volume - A sonar caliper will be evaluated for its capabilities to measure cavern volume while the cavern is partially filled with crude oil.

(d) Roof fall - Several techniques will be evaluated for their ability to detect roof fall. Included will be acoustic emissions monitoring, hydrophones in the cavern, pressure transducers in the cavern, pressure transducers on the wellhead and strain measurements near the bottom of the casing.

(e) Wellbore competence - A closed-circuit television (CCTV) system will be evaluated for inspection of brine-filled wells.

(f) Cavern pressure - Systems which will detect high and low pressures at the wellheads and produce alarms will be evaluated.

(g) Oil-brine interface - Electromagnetic and sonic relfections from the oil-brine interface will be evaluated as techniques to measure the depth of the interface without the necessity of using wireline equipment.

(h) Change in salinity - Brine salinity change measurements to indicate potential cavern self-leaching are planned for development and evaluation for use in caverns not being used for oil storage.

(2) Site Stability

(a) Tiltmeters will be evaluated for monitoring site subsidence.

(3) Stored Oil Quality and Quantity

(a) Casing integrity – A CCTV system will be evaluated for casing inspection.

(b) Interface measurements – See no. (7) in the Cavern Integrity section.

III. Measurements Procedures

Data at field site locations will be acquired by one of a variety of data acquisition systems. The most broadly scoped system, which is mounted in a mobile trailer, is a highly versatile computerized system capable of recording a broad range of transducer inputs on 120 low and 10 high sample rate (1 sample/minute and 10K sample/sec) channels (Ref 2). This data can be presented locally in a basic real time data analysis mode (print or plot) to determine data acquisition quality. Stored data (disk and tape) is compatible with scientific computers at Sandia where complete analyses of the data will be performed. The primary purpose for this system will be to evaluate measurement techniques and instrumentation systems at the Bayou Choctaw SPR Site prior to application at other sites.

More portable, less complex systems (similar to that used for West Hackberry Cavern 6 recertification) will be used for data acquisition at other sites.

Prior to expending funds for time and materials required to field test an instrumentation system or technique, a test plan must be approved by the Supervisor of the SPR Geotechnical Division at Sandia National Laboratories. The test plan should be of the form outlined in Appendix A.

Field tests which require the support of other SPR contractors will require the approval of the SPRPMO.

IV. RESULTS

The results of each specific field evaluation of instrumentation will be data which include but are not limited to:

(1) Total system accuracy,

(2) Total system resolution,

(3) Sensitivity to changing environmental conditions,

(4) Total system hysterisis,

(5) System drift,

(6) System reliability,

(7) Installation requirements,

(8) Maintenance requirements, and

(9) cost.

It is not planned to perform a detailed reliability study for each system tested. Rather, the system will be compared to similar systems for observed failures.

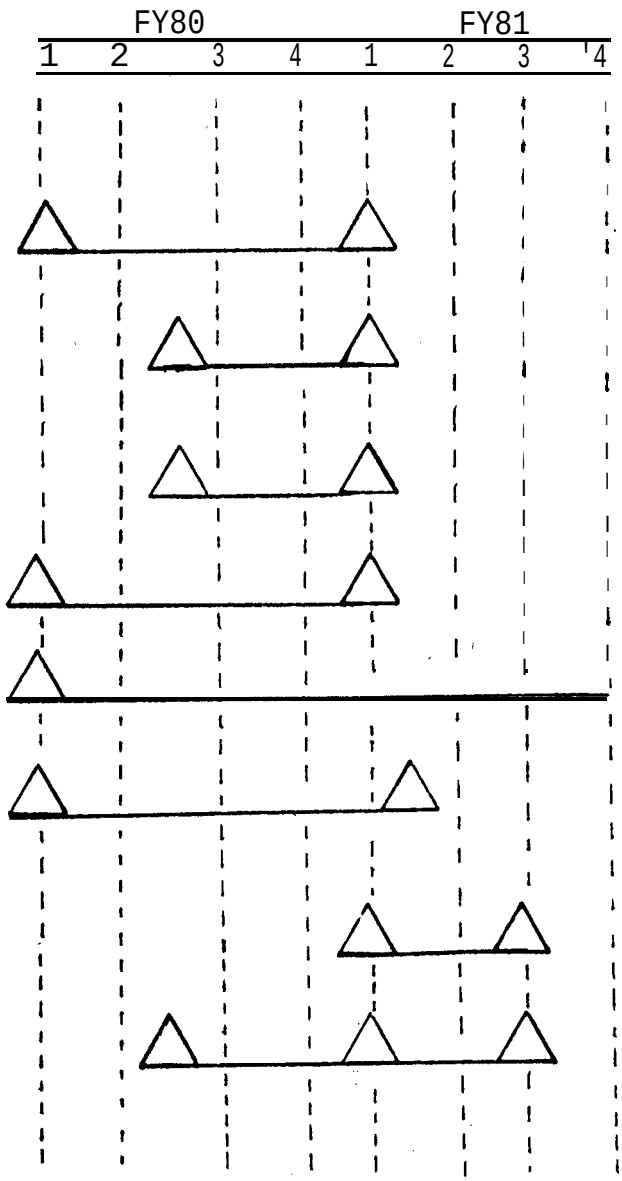
The results will also include a report which details the actual test procedures and conditions.

It is expected that these results will be used to make recommendations for instrumentation to be used in site characterization, engineering evaluation and long-term monitoring.

V. SCHEDULE

Table I presents the schedule for the field measurements task including the early field tests which will. be performed.

TABLE I. SCHEDULE



Activity

Develop data acquisition system for Bayou Choctaw evaluation site.

Develop data acquisition system for other sites.

West Hackberry Cavern 6 Recertification

Develop Field Measurements Plan

Develop detailed test plans.

Develop schedule for field tests.

Field test acoustic emission system

Field test tiltmeters

References

1. Walker, H. C., "SPR Geotechnical Program Preliminary Long-Term Monitoring Plan," SAND80-1750, August 1980.

2. Merilatt, P. D. and A. G. Bauer, "Strategic Petroleum Reserve Data Acquisition System," SAND80-2143, October 1980.

Appendix A

OUTLINE FOR FIELD TEST PLAN FOR INSTRUMENTATION EVALUATION

I. OBJECTIVE

The objective of the evaluation of the instrumentation should be clearly stated. That is, the question of what the SPR program will gain from the evaluation should be answered.

II. 'BACKGROUND

Studies of prior use of the instrumentation or technique should be summarized.

III. IMPLEMENTATION SCHEDULE

A. Development (if required)

B. Test dates

c. Data Analysis

IV. SOFTWARE DEVELOPMENT

Any expected modification to the existing test software or development of test specific off line analysis software should be included.

V. COSTS

A. Field Test

(1) Sandia loaded labor

(2) Purchase of instrumentation

(3) Services to be supplied by other SPR contractors

(4) Material required for test

B. Final System

(1) Purchase of instrumentation

(2) Maintenance

(3) Installation

VI. SUMMARY

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